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A HISTORY OF SELF-SELECTION OF DIET. I.

By RUTH WOODS

The question as to whether animals and human beings are capable of selecting adequate types and amounts of foods under conditions of free choice has aroused the curiosity of both scientist and layman for many years. Records of both trained and casual observations through the years, as well as the results of specially designed experiments, would seem to indicate a more or less positive answer to this question. The nature of the evidence thus obtained, however, still remains far from conclusive. Assuming, however, that such choices can be and are made, a number of further intriguing questions remain: What is the basis for such choices? Is it instinct or is it a matter of "learned" appetite; is it a subtle alteration in physiological conditions which stimulates a response to special nutrients; is it a matter of varying taste thresholds under special conditions? Again, assuming such choices are made, what is the significance of this phenomenon in terms of practical physiology and nutrition?

The present review will summarize briefly some of the observations constituting the historical and anthropological background for the thesis of self-selection. A subsequent issue will review the experimental scientific evidence both for and against the existence of proper self-selection of diet by animals and man, and at the same time, will attempt to provide an answer to the foregoing questions.

Observations on Animals: The concept that animals can make suitable dietary selections from available foods has gained much support from observations on many different species, particularly during the last thirty-five years. In 1915, for example, Evvard (1) at the Iowa Agricultural Experiment Station reported that pigs allowed a free choice of diet made very good selections and grew remarkably well. One of these animals, in fact, grew to be the largest hog ever raised at the Experiment Station. He concluded that the appetite of the pig is apparently a very good guide as to its bodily needs. Since then, numerous similar findings have been reported with other animals. Thus, dairy cows were observed to make wise dietary selections as evidenced by milk output and weight gains (2); sheep grazing in pastures containing mineral deficient areas were observed to consistently avoid the deficient areas (3); cattle have been shown to be capable of distinguishing hays of different nutritive qualities, preferring hays grown on fertilized soil (4). Similar beneficial selections by livestock have been reported by Orr (5). Chicks allowed a free choice of foodstuffs ate less protein and fat, slightly

more carbohydrate and 10% less calories than did chicks on a mixed diet of similar ingredients (6). Since both groups grew at about the same rate and laid about the same number of eggs, it was apparent that those on the self-selected diet were utilizing their food more efficiently. Another investigator, however, studying free choice in chicks found two types of behavior, one indicating wise choice and the other, poor choice (7). Chicks fed a mixture of the foods which had been selected by the *slow-growing* birds grew faster and made more efficient use of their food than did those which selected the food. On the other hand, chicks fed a mixture of foods selected by the *fast-growers* grew more slowly and used the food less efficiently than those which selected the food. This seemed to indicate that the order in which nutrients are consumed may have some significance in determining the nutritional value of the diet.

Observations on Man: In a review of the literature on comparative and historical dietetics, Mursell (8), in 1925, wrote:

> "When we find widely sundered races with vast differences in tastes and preferences, in food opportunities and in habitat, still keeping to pretty much the same general balance of rationing, it is difficult to avoid the impression that we are in the presence of a very powerful auto-regulative mechanism which, given certain external conditions, strongly favors a certain proportion of intake from among the basic nutrient substances."

There are numerous instances in support of this belief to be found in the history of the food habits and customs of various populations. In Mexico, for example, a common practice in the preparation of tortillas involves the preparatory soaking of corn in a lime solution. By this means an appreciable quantity of calcium is absorbed and introduced into the diet in a region where the production of calcium-rich dairy products is impracticable. In the rural, cereal consuming areas of North China, cereals are eaten as mixtures: rarely as single grains. The biological value of the mixed cereals has been found to be invariably superior to that of single cereals (because of supplementation). The combinations of cereals were found to provide protein mixtures of high, often maximum, biological values (9). Inhabitants of the island of Naura in the Pacific at one time included in their diet a toddy or fermented alcoholic drink made from the flower of the coconut palm. When the island was incorporated under the Commonwealth of Australia the preparation of the toddy was prohibited. This was followed by a coincident rise in infant mortality, an occurrence which was traced to beriberi resulting from the prohibition of the beverage. Toddy yeast had been used by the natives to cure beriberi in babies (10). Again in China, the preparation of soy beans reflects an instinctive nutritional wisdom. Soybeans, unless subjected to pro-

longed heat treatment, are nutritionally inadequate. In the Orient where soybeans form a large part of the diet the vegetable is not cooked but is subjected to various processes, including germination (bean sprouts), fermentation (soy sauce) or fractionation (soy bean curd). Each of these processes has been shown in some way to improve the nutritive value of this food.

Studies of Primitive Cultures: Of the primitive peoples noted for their wise choice of food, the Hunzas of Northern India are perhaps the most renowned and extensively written about. Unlike neighboring tribes, the Hunzas are extremely hardy, possess superior powers of strength and endurance, enjoy buoyant health. Further, they excel as skilled workmen and artisans and are of generally superior intelligence. During a seven year period of close observation and work among these people, McCarrison (11) was led to the conclusion that diet was the outstanding factor responsible for the marked superiority of the Hunzas over the rest of the Indian population. Their diet, although neither varied nor abundant, provided the essentials required for good nutrition. They consumed cereal grains, vegetables, fruits (especially iron-rich apricots), milk and butter daily. Goat's meat was eaten on feast days. As described by Rorty and Norman (12):

> "On these meager rations the Hunzas lived long and merrily, mocked at their morose and dyspeptic neighbors and gave McCarrison as their physician so little to do that his case records dealt mostly with accidents, the removal of senile cataract, etc."

In order to check his theory on the influence of the Hunza diet on health, McCarrison fed one group of rats a diet based on that of the Hunzas and another group diets typical of those of the undersized, disease-ridden Bengalis and Madrassie of the South of India. The rats fed the Hunza diet, thrived and grew normally, mated normally and had healthy offspring and manifested no ills.

The rats fed diets typical of the inhabitants of Bengal, Madras, Travancore and other parts of India—polished rice, tapioca, pulses, vegetables, spices and a small amount of milk—soon acquired a host of diseases, including pneumonia, sinusitis, ulcers and cancer of the stomach, pernicious anemia, enlarged glands, enlarged adenoids, goiter, polyneuritis, heart disease, premature birth. The temperament of the animals was also affected. Those fed the Hunza diet were gentle, playful and affectionate; others fed a diet similar to that of the poorer classes in Britain became irritable and vicious in behavior.

Not only the diet of the Hunzas, but their agricultural practices—prescribed by rigid tradition — have been found to be extraordinarily well

planned. Their fields are terraced in staircase fashion and the soil is irrigated and renewed by the silt-bearing water which is brought down by aqueducts from the glaciers of the surrounding mountains. This provides a never-ending source of mineral supplements. All human, animal and vegetable refuse is meticulously returned to the soil. These methods provide a permanent, balanced agriculture, a fertile soil requiring no artificial fertilizers and crops which are relatively immune to the parasites and diseases common to the farmer in the western hemisphere.

Price (13) has reported the remarkable absence of dental caries and modern degenerative diseases among numerous primitive tribes throughout the world and has demonstrated a direct influence of diet on these conditions. His studies included observations on the Gaelic fishermen of the Outer Hebrides, various tribes of East and West Africa, the Maoris of New Zealand, the Melanesians, Polynesians and other South Sea cultures, the aborigines of Australia and the Torres Straits, modern Indians in the Peruvian Andes, the Seminoles of the Florida Everglades, various Indian and Eskimo tribes throughout Canada and Alaska. In general he found that primitive peoples with a high survival quotient often choose from the natural foods available to them a diet of extraordinary excellence. The best primitive diets were found, on analysis, to be far higher in essential vitamins and minerals than the average civilized diet. As long as these diets are followed, dental defects are almost entirely absent and health is excellent. As soon as "store food," white flour, granulated sugar and other refined foods of our civilization are introduced and used, dental decay, tuberculosis and arthritis appear and resistance to disease in general is greatly diminished. Among the natural foods selected by these various peoples are all forms of sea food, animal glands and organs, well-fertilized grains, the livers of fish, animals and, among cannibal tribes, of humans.

Special Diets: Tribal custom and religious rites play an important role in prescribing special diets for assuring fertility and for use during pregnancy and lactation (12). Thus, in many African tribes girls are fed special foods prior to marriage. Among the Masai, for example, girls must wait for marriage until the cows are eating young grass. Only after they have drunk the milk from these cows for several months is marriage permitted.

Among the special foods prescribed for adolescent girls and pregnant women are fish eggs, fresh blood, the ashes of certain plants. During Old Testament days, tribal custom prescribed a prenatal diet rich in protein, vitamins and minerals consisting of wheat, barley, parched corn, beans, lentils, olives, butter, honey, cheese, lamb, fowl, oxen and fresh fruits.

Extreme starvation will often minimize the effects of food habits and prejudices, permitting "instinctive" choice of nutritionally superior foods. This is illustrated by Englander's (14) account of the situation among a group of American soldiers in a German prison camp during World War II: The great event of the camp was the arrival of Red Cross food parcels. Trading went on among the men and a point system was set up which reflected fairly well the nutritional value of the food. A can of powdered whole milk topped the list at 150 points, meat followed at 120 and so on down the scale for other foods which included cheese, jam, sugar and the chocolate D bar.* The reason given for the popularity of powdered milk was that "it satisfied —even more than chocolate—the prisoners' craving for something rich to eat." This is especially significant because powdered milk was not generally popular among the American soldiers.

In contradistinction to these examples are numerous instances of how religious, social and economic customs, superstitions and the influences of "civilization" have interfered with the natural selection of adequate diets.

An interesting example is the study reported by Orr and Gilks (15) on the food habits of two neighboring East African tribes, the Masai and the Akikuyu. The Masai live almost entirely on meat, milk and fresh blood. They are healthy and vigorous. The Akikuyu, on the other hand, live chiefly on cereals and potatoes. The eating of green vegetables is considered effeminate and further, according to Akikuyu superstition, prevents the men from being swift of foot, if defeated in battle by the Masai. Although they maintain herds of goats, economic custom has resulted in these being used for currency instead of as a source of meat or milk. For these reasons, the Akikuyu—particularly the males—are less healthy and sturdy than their neighbors. The average male adult is about 5 inches shorter and 23 pounds lighter than the Masai male. The children suffer from bone deformities, anemia and enlarged tonsils.

The adverse influence of "civilization" has been demonstrated many times. The introduction of modern, refined foods to natives of the South Seas, for example, has resulted in the development of dental caries among populations where this disease has been largely unknown (13). Even among populations more advanced culturally, the effects of further civilization have been harmful. In Labrador and Newfoundland, for example, brown bread constituted a large part of the diet during the winter and spring. With the advent of modern food customs, white bread was introduced and soon replaced the brown bread. Beriberi, heretofore unknown, soon became a widespread disease. In 1910, it is reported (16) a ship ran ashore laden with a

*These are not necessarily in order, point values for these not having been reported.

cargo of whole wheat flour, much of which was unloaded to lighten the ship. As a result the population again consumed whole wheat bread and beriberi disappeared for a year. Subsequently the people returned to the habit of eating white bread and beriberi soon reappeared. Thus, although the people had no objection to whole wheat flour, they failed to profit from experience, returning to white flour because of its availability and habit.

In general, however, it has been concluded by many authorities that primitive human populations show an amazing ability to choose foods in accordance with their physiological needs, provided their choice is not unduly influenced by education, imitation and other factors such as those cited above.

As Lepkovsky (17) has pointed out:

> "To survive, animals must ingest foods which supply the essential nutrients necessary for growth and reproduction. To survive, they must choose adequate foods, for in any given environment animals can easily choose foods which will not meet their nutritional needs. The existence of a rich animal population is proof that they have chosen adequate foods."

The Phenomenon of Perverted Appetites:

The occurrence of perverted appetites or pica has been observed in both animals and man. The phenomenon is characterized by a desire to eat non-food materials which may include earth, bones, excreta, chalk, ashes and the like. Analysis of this behavior, particularly in animals, frequently has revealed that such practices constitute an attempt on the part of the animal organism to obtain some necessary food element which is missing from the diet. Thus, it has been noted that cattle in South Africa fed on vegetation growing on phosphorus-deficient soil, suffer from osteomalacia and subsequently develop an unusual craving for bones (a source of calcium and phosphorus) and thereby cure their deficiency (18, 19). Similarly, it has been found that sheep in New South Wales cured themselves of "weakness" by eating certain earths (20). Analysis of these special earths revealed them to be unusually rich in iron. In Victoria, Australia, it has been reported that horses grazing on inferior pasturage, compensate for the calcium deficiency of the grasses by eating the bark of "grey-box" trees (5). This material is exceedingly rich in calcium, containing 53.7% as compared to 2.7% in the grasses. Some interesting observations on the behavior of normally fed pigs and pigs on diets deficient in calcium and vitamin A have been reported by Drummond (21). Those on the normal diet, when allowed to exercise in a yard, were quiet or strolled about contentedly. The calcium-deficient animals spent a large part of their time licking whitewash from the walls or rooting out bits of cement or mortar from the brickwork (all

sources of calcium salts); while the vitamin A deficient animals searched avidly for such weeds or blades of grass as might be growing in the cracks of the ground.

Laboratory Observations: Laboratory animals on experimental diets deficient in one or more nutritional essentials frequently display various appetite perversions. One of the most common of these is coprophagy or feces eating which has been shown to provide the animal with a source of the vitamin B complex.* This practice is so widespread that special precautions must be taken to prevent access to feces in order to obtain accurate data on the intake of the various dietary essentials. Orent-Keiles and McCollum (22) have reported an unusual type of behavior in rats on a diet deficient in potassium which was characterized by a marked tendency of the animals to lick themselves after urinating. Since potassium is excreted almost entirely in the urine, it has been concluded that the animals were attempting to recover the deficient element from the urine. No evidence of coprophagy was observed in these animals.

The eating of young, rapidly growing tumor tissue (23) or even self-eating of injured tissue (24) or the eating of offspring are all believed to be evidence of the operation of self-regulating mechanisms guiding the appetites of the animal (23). An example of the latter is the observation by McCollum (25) that hens on experimental diets designed to determine whether birds could synthesize lecithin, developed such a strong habit of egg eating that they had to be carefully watched in order to secure the eggs immediately after they were laid. Since egg yolk is an extremely rich source of lecithin, the possibility is quite strong that the animals were attempting to obtain a supply of the deficient material.

Human Observations: Unusual eating behavior in children has been reported frequently. Dirt eating and chalk (calcium carbonate) eating are the most common of the aberrations observed, but because of non-controllable circumstances, it has not always been possible to trace these actions to specific nutritional deficiencies. The practice of earth eating has been found to be very common among certain East African tribes. Orr and Gilks (15) have noted that the search for edible earths rich in calcium often resulted in tribal wars. These tribes also made use of the ashes from water plants having a very high calcium content, the material being especially popular among pregnant women in whom calcium requirements are greatly increased. Analysis of the most popular of the edible earths consumed revealed them to be unusually rich in either calcium, sodium or iron.

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*Synthesized by intestinal bacteria; *cf. Borden's Review of Nutrition Research,* May, 1946, "The Biosynthesis of Vitamins."

Abnormal physiological conditions similarly have been shown to result in a craving for unusual substances or unusual amounts of ordinary foods. Thus children with parathyroid deficiency (defective calcium metabolism) have been found to eat chalk, plaster and other materials rich in calcium. Certain people of the poorer classes in the South are known to eat clay in order to cure anemia. Similarly, pregnant Negro women in the South often travel long distances to gather "stump dirt," a type of iron-rich clay found where a large tree blows over and brings the subsoil to the surface.

Conclusion:

As early as 1897, Sir William Roberts (26) remarked:

> "The generalized food customs of mankind are not to be viewed as random practices, adopted to please the palate or gratify an idle or vicious appetite. These customs must be regarded as the outcome of profound instincts which correspond to certain wants of the human economy. They are the fruit of a colossal experience accumulated by countless millions of men through successive generations."

In the decades that followed this statement, anthropologists and nutrition authorities have recorded numerous instances in support of this contention. The concept of the intuitive wisdom of the body in meeting its physiological needs through adaptive mechanisms, particularly as reflected by appetite behavior, had its scientific origins in the works of the pioneer physiologist, Claude Bernard, and later, of Cannon. In recent years the phenomenon of self-selection of diet and the operation of self-regulatory mechanisms has been subjected to considerable scientific investigation under controlled laboratory conditions. The results and interpretations of these experimental findings will be summarized in the following issue of this Review.

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NEWS DIGEST

BETAINE IN METHYLATION: The value of betaine as a source of methyl groups in animal nutrition is emphasized by recent research. Studies at California Institute of Technology indicate a higher lability of the methyl groups of betaine than those of choline. Choline's methyl groups become available for methionine formation from homocysteine only if the animal can oxidize choline to betaine. *In vitro* studies show that methionine formation is rapid from betaine, dimethylthetin and certain of its derivatives, both aerobically and anaerobically, in all animals tested, but choline is effective as a methyl group source only in those animals which have the enzyme choline oxidase. Rabbits. guinea pigs, and chicks do not have choline oxidase and thus do not form methionine from choline in liver and kidney homogenates aerobically or anaerobically.

Other studies at Purdue University indicate that betaine is at least equal and may be superior to choline and methionine in supplementing simplified corn-soybean poultry rations. This work supports previous findings that, although certain levels of choline and methionine are indispensable for other vital body functions, betaine replaces them very well as a source of methyl groups for the body process of methylation.—*Proc. Fed. Am. Soc. Exptl. Biol. 8,* 195 (1949); *Poultry Sci. 28,* 24 (1949).

CABBAGE JUICE IN PEPTIC ULCER: A newly developed treatment for peptic ulcer involves a special diet, the major feature of which is fresh cabbage juice in amounts of at least 1 liter (2.2 quarts) per day. Cabbage juice is believed to be a potent source of the so-called antipeptic ulcer factor, tentatively named "vitamin U." The diet, which eliminates all fresh and uncooked foods (potential sources of vitamin U) except cabbage juice, was given to a small group of hospitalized ulcer patients. Only cooked foods were given, because heating destroys the anti-peptic ulcer factor, the only source of the factor being the cabbage juice. The amount of juice given is based on body weight of the patient, the calculations having been derived from studies with guinea pigs which showed that 2 gm. of cabbage leaves or 4 cc. of juice protect against histamin-induced ulcers in animals weighing about 300 grams. The average healing time for all the patients was 9 days; one or two cases extended to about 23 days. Average time in duodenal ulcer patients on the customary ulcer treatment regimen (hospitalization, bland diet, frequent milk feedings, alkalization, sedatives, tobacco restriction, anti-spasmodic drugs, etc.) is 37 days, with a range of 13 to 68 days, as compared to 10.4 days on the cabbage juice diet. Gastric ulcers healed in an average of 9.3 days compared to a general average of 42 days for similar patients receiving conventional ulcer therapy. — *Calif. Med. 70,* 10 (1949).

REFINING SOY BEAN OIL: A new method of refining soybean oil with citric acid has been developed whereby both the flavor and keeping quality of the oil have been improved. The citric acid combines with tiny metallic traces dissolved in the soybean oil, possibly from contact with metal containers or equipment. These minute quantities of metal hasten the development of off-flavors in the oil, if they are not deactivated by the citric acid. The soybean oil refined by this process keeps three to five times longer than that refined by current methods. The adoption of this process by industry could expand the market for soybean oil and also lower the cost of salad oil or dressing to consumers.—*J. Am. Diet. Assoc. 25,* 268 (1949).

PEANUT FLAVOR IN ICE CREAM: The popular nut flavors in ice cream include pecan, walnut, pistachio, and burnt almond. A recent addition to these flavors is that of processed peanuts which contain thiamine, riboflavin, niacin, and easily digested, high-grade fat and protein. Peanut brittle is another form of nut flavor which can be utilized. Nut flavors in paste form have also recently been developed.—*Ice Cream Trade J. 45,* 56 (1949).

CALCIUM REQUIREMENT IN AGING: A recent report from the New York State Experiment Station, states, "Thousands of older people and animals are losing their bones every day they live. The bones slowly dissolve and become so weakened and brittle that they break easily and then may never heal properly, if at all. Because people cannot see their bones dissolving and weakening, they do little or nothing to prevent it until it is too late."

Studies with rats have shown that unless the diet of an aging rat contained about 3/10 per cent of calcium, more calcium was excreted than was eaten, indicating a net loss of this mineral from the bones, since 99 per cent of the calcium in the body is in the bones. Another study with dogs showed that when their ration contained only a small quantity of calcium, there was a daily loss. When the diet contained enough calcium to compare with a pint of milk in a human diet, the dogs excreted only a fourth as much calcium.—*J. Am. Diet. Assoc. 25,* 354 (1949).

CUP-FEEDING OF NEWBORN: Results of a ten-year nutrition study indicate apparent advantages in the artificial feeding of newborn babies by cup or glass, rather than by bottle. Less time is required—only 5 to 10 minutes; the swallowing of air is minimized, thereby reducing the incidence of colic. It has also been suggested that such a technique may prevent hunger strikes by the baby and frustration of the mother at the time of weaning, and that the introduction of solid food at three or four months appears to be easier. Cup-fed babies have gained weight as rapidly as breast- and bottle-fed infants. It is noted that this technique is particularly well suited for premature infants and those with hairlip and cleft palate, since they may have minimal sucking capacity. It is also thought that the cup-feeding had advantages with infants who are suffering from upper respiratory diseases.

It is also pointed out that cup-fed babies have physical contact with the mother, similar to that of the breast-fed child, since a cup or glass can't be propped up on a pillow in the crib beside the baby, as is often done with bottle-fed babies.

In using the cup or glass, the child is held in the mother's or nurses arm as for breast-feeding. The infant's mouth makes movements with the lower jaw which regulate the flow of milk, and automatically prevents choking in this way. However, care must be taken to prevent excess spilling. The baby's hands are held to prevent its knocking the glass or cup aside. When sufficient nourishment has been taken, the baby pushes the glass away. No signs of frustration or compensatory thumb-sucking were noted in cup-fed babies as compared to breast and bottle-fed infants.—*Pediatrics 2,* 544 (1948).

METHIONINE IN LIVER DISEASE—Methionine has been used successfully in the prevention and treatment of dietary liver injury in experimental animals. Its clinical value for man, however, has yet to be conclusively demonstrated. Studies have been based on the rate of removal from the blood of methionine administered intravenously and the subsequent excretion of methionine and sulfate sulfur

in the urine. Normal individuals were compared with patients with hepatitis and with hepatic cirrhosis.

There seemed to be distinct differences between the normal individuals studied and those with liver disease with respect to the metabolism of the methionine administered intravenously. Although over 90 per cent of the fasting plasma l-methionine concentrations fell within the normal range, some were above normal, and a few were quite high, chiefly in very severe, active liver disease. After infusion of 50 ml. of a 3 per cent dl-methionine solution injected over a five minute period, peak blood values obtained fifteen minutes after the injection declined rapidly up to the thirty minute postinjection sample; thereafter the decline was slower up to one hundred and eighty minutes after the injection was given. There was evidence that the initial rapid fall was associated with diffusion of methionine out of the blood plasma but that the slower subsequent fall was more likely related either to the absorption of the amino acid into body tissue or actual utilization, either anabolic or catabolic. The rate of methionine removal from the plasma in acute hepatitis and in cirrhosis was statistically slower than in the normal group. During convalescence from acute hepatitis the rate of disappearance became normal or, in some instances, greater than normal. Two of 3 individuals with chronic hepatitis had a normal rate of removal of plasma methionine after injection.

Urinary excretion of methionine and of sulfate following the administration of methionine intravenously to patients with liver disease differed little if any from that in the normal individuals.—*Nutr. Rev.* 7, 127 (1949).